

CLAIMS

1. An exhaust purification device for internal combustion engine, comprising:

5 a catalytic converter provided in an exhaust passage of an internal combustion engine,

an air/fuel ratio forcibly modulating element for forcibly modulating the air/fuel ratio of exhaust flowing into the catalytic converter, between a lean air/fuel ratio leaner than a target average air/fuel ratio and a rich  
10 air/fuel ratio richer than the target average air/fuel ratio, with a specific period, a specific amplitude, a specific modulation ratio and a specific waveform,

an oxygen sensor provided in the exhaust passage for detecting the oxygen concentration of the exhaust and  
15 supplying an output corresponding to the detected oxygen concentration,

a time ratio calculating element for obtaining the ratio of a time for which the output of the oxygen sensor is greater than a standard value for the output set between  
20 the maximum and minimum values of the output, or of a time for which the output of the oxygen sensor is smaller than the standard value for the output, in a predetermined period of time, or a value correlating with the ratio, and

an air/fuel ratio adjusting element for adjusting the  
25 air/fuel ratio of the exhaust during the forcible modulation, on the basis of the ratio or the value correlating with the ratio obtained by the time ratio calculating element.

2. The exhaust purification device for internal  
30 combustion engine according to claim 1, wherein

the predetermined period of time is an integer times the period of the modulation.

3. The exhaust purification device for internal

combustion engine according to claim 1, wherein

the period of the modulation is set to be equal to or shorter than a maximum period which ensures the air/fuel ratio to be detected on the basis of the output of the oxygen sensor does not reach the upper or lower limit of a range of air/fuel ratios detectable by the oxygen sensor.

4. The exhaust purification device for internal combustion engine according to claim 1, wherein

the air/fuel ratio forcibly modulating element performs the forcible modulation so that the output of the oxygen sensor varies passing through a switch point of an output characteristic curve of the oxygen sensor.

5. The exhaust purification device for internal combustion engine according to claim 4, wherein

the standard value for the output is set to an output value at the switch point or in the vicinity of the switch point.

6. The exhaust purification device for internal combustion engine according to claim 1, wherein

the oxygen sensor has a catalytic function.

7. The exhaust purification device for internal combustion engine according to claim 1, wherein

the air/fuel ratio adjusting element adjusts the air/fuel ratio of the exhaust during the forcible modulation, on the basis of a difference between the ratio or the value correlating with the ratio obtained by the time ratio calculating element and a standard value for the ratio.

8. The exhaust purification device for internal combustion engine according to claim 1, wherein

the value correlating with the ratio is obtained, when the ratio is greater than the standard value for the ratio, by correcting the ratio in a manner such that the ratio is

more increased when the period of the modulation is longer and more decreased when the period of the modulation is shorter, and when the ratio is smaller than the standard value for the ratio, by correcting the ratio in a manner  
5 such that the ratio is more decreased when the period of the modulation is longer and more increased when the period of the modulation is shorter.

9. The exhaust purification device for internal combustion engine according to claim 1, wherein  
10 the value correlating with the ratio is obtained, when the ratio is greater than the standard value for the ratio, by correcting the ratio in a manner such that the ratio is more increased when the amplitude of the modulation is greater and more decreased when the amplitude of the  
15 modulation is smaller, and when the ratio is smaller than the standard value for the ratio, by correcting the ratio in a manner such that the ratio is more decreased when the amplitude of the modulation is greater and more increased when the amplitude of the modulation is smaller.

20 10. The exhaust purification device for internal combustion engine according to claim 1, wherein  
the value correlating with the ratio is obtained, when the ratio is greater than the standard value for the ratio, by correcting the ratio in a manner such that the ratio is  
25 more increased when the waveform of the modulation is closer to a square wave and more decreased when the waveform of the modulation is further from the square wave, and when the ratio is smaller than the standard value for the ratio, by correcting the ratio in a manner such that  
30 the ratio is more decreased when the waveform of the modulation is closer to the square wave and more increased when the waveform of the modulation is further from the square wave.

11. The exhaust purification device for internal combustion engine according to claim 1, further comprising a rotational speed detecting element for detecting the rotational speed of the internal combustion engine, wherein  
5 the value correlating with the ratio is obtained, when the ratio is greater than the standard value for the ratio, by correcting the ratio in a manner such that the ratio is more increased when the rotational speed of the internal combustion engine detected by the rotational speed  
10 detecting element is higher and more decreased when the rotational speed is lower, and when the ratio is smaller than the standard value for the ratio, by correcting the ratio in a manner such that the ratio is more decreased when the rotational speed is higher and more increased when  
15 the rotational speed is lower.

12. The exhaust purification device for internal combustion engine according to claim 1, further comprising an exhaust flow rate detecting element for detecting the flow rate of the exhaust, wherein  
20 the value correlating with the ratio is obtained, when the ratio is greater than the standard value for the ratio, by correcting the ratio in a manner such that the ratio is more increased when the flow rate of the exhaust detected by the exhaust flow rate detecting element is greater and  
25 more decreased when the flow rate of the exhaust is smaller, and when the ratio is smaller than the standard value for the ratio, by correcting the ratio in a manner such that the ratio is more decreased when the flow rate of the exhaust is greater and more increased when the flow rate of  
30 the exhaust is smaller.

13. The exhaust purification device for internal combustion according to claim 1, wherein  
the standard value for the ratio of the time for which

the output of the oxygen sensor is greater than the standard value for the output, or for the value correlating with the ratio is in the range of 0.5 to 0.75.

14. The exhaust purification device for internal  
5 combustion according to claim 1, wherein

the standard value for the ratio of the time for which the output of the oxygen sensor is smaller than the standard value for the output, or for the value correlating with the ratio is in the range of 0.25 to 0.5.

10 15. The exhaust purification device for internal combustion according to claim 1, wherein

the air/fuel ratio forcibly modulating element includes a change element for making change according to the operating states of the internal combustion engine, and

15 the time ratio calculating element stores changed periods of the modulation in the past, and obtains the value correlating with the ratio, from the time for which the output of the oxygen sensor is greater than the standard value for the output or the time for which the  
20 output of the oxygen sensor is smaller than the standard value for the output, obtained this time, and a past changed period of the modulation stored.

16. The exhaust purification device for internal combustion according to claim 1, wherein

25 the air/fuel ratio forcibly modulating element includes a change element for making change according to the operating states of the internal combustion engine, and

the time ratio calculating element stores the time for which the output of the oxygen sensor was greater than the  
30 standard value for the output or the time for which the output of the oxygen sensor was smaller than the standard value for the output, obtained last time, and obtains the value correlating with the ratio, from the time for which

the output of the oxygen sensor is greater than the  
standard value for the output, obtained this time, and the  
sum of the time for which the output of the oxygen sensor  
is greater than the standard value for the output, obtained  
5 this time, and the time for which the output of the oxygen  
sensor was smaller than the standard value for the output,  
obtained last time, or from the time for which the output  
of the oxygen sensor is smaller than the standard value for  
the output, obtained this time, and the sum of the time for  
10 which the output of the oxygen sensor is smaller than the  
standard value for the output, obtained this time, and the  
time for which the output of the oxygen sensor was greater  
than the standard value for the output, obtained last time.